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CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS. III.

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Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

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CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS. III.

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ABSTRACT

Seventeen candidate insecticides were evaluated for direct-contact, residue, and vapor toxicity to adults of the confused flour beetle, *Tribolium confusum* Jacquelin duVal, and larvae of the black carpet beetle, *Attagenus megatoma* (Fabricius). The most promising insecticides against both insect species were methidathion and Shell SD 9020 for direct-contact toxicity; methyl parathion and Shell SD 9020 for residue toxicity; and Chemagro 4637, Chemagro 4641, Chemagro 4671, methyl parathion, Shell SD 9020, and Virginia Carolina VC 3–668 for vapor toxicity. The most persistently effective insecticide residues were methidathion, methyl parathion, Rhodia 11783, Rhodia 11807, Shell SD 9020, and Shell SD 9098.

INTRODUCTION

The Stored-Product Insects Research and Development Laboratory at Savannah, Ga., conducts a continuous research program on the evaluation of promising new insecticides as direct-contact, residue, and vapor toxicants in a search for more effective, safer, and less costly insecticides for protecting food, feed, seed, and other agricultural commodities against insect infestation. In preliminary tests these insecticides were evaluated against two representative species of stored-product insects, adults of the confused flour beetle, *Tribolium confusum* Jacquelin duVal, and larvae of the black carpet beetle, *Attagenus megatoma* (Fabricius). The information obtained from these tests is used for selecting new insecticides for further evaluation in various other phases of our research.

Tests on other groups of compounds evaluated in this program were reported in Marketing Research Report (MRR) No. 546 in 1962 [1] and in MRR 885 in 1970.[2] The candidate insecticides included in this report and their chemical names are given in table 1.

PROCEDURE

The insects used in these tests were 7- to 14-day-old adults of the confused flour beetle and 3- to 5-month-old larvae of the black carpet beetle. The insects were reared under the same conditions as those described in MRR 885.

Insect-exposure techniques were different for each test method; however, assessment of insect response to exposure to the candidate insecticides was the same. Insects that could not walk or remain in an upright position were recorded as inactive (I), and those that did not move or responded only feebly when probed lightly were recorded as dead and moribund (D+M).

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[1] Speirs, R. D. 1962. Contact, residue, and vapor toxicity of new insecticides to stored-product insects. U.S. Dep. Agric. Mark. Res. Rep. No. 546, 31 pp.

[2] Speirs, R. D and Lang, J. H. 1970. Contact, residue, and vapor toxicity of new insecticides to stored-product insects. II. U.S. Dep. Agric. Mark. Res. Rep. No. 885, 35 pp.

TABLE 1.—*Candidate insecticides*

ENT No.[1]	Company or common name	Chemical name
27089	American Cyanamid 47772.	Imidocarbonic acid, (phosphonodithio-,)-cyclic propylene *P*,*P*-dimethyl ester.
25996	Bay 52957	Phosphorothioic acid, *O*-(5-chloro-1,2-benzisoxazol-3-yl) *O*,*O*-diethyl ester.
27162	Bromophos	Phosphorothioic acid, *O*-(4-bromo-2,5-dichlorophenyl) *O*,*O*-dimethyl ester.
25971	Chemagro 4637	Phosphorothioic acid, *S*-(1,2-dichlorovinyl) *O*,*O*-dimethyl ester.
25972	Chemagro 4641	Phosphorothioic acid, *S*-(2,2-dichlorovinyl) *O*,*O*-dimethyl ester.
25973	Chemagro 4671	Phosphorothioic acid, *O*,*O*-dimethyl *S*-(1,2,2-trichloroethyl) ester.
27238	Geigy GS–12968	Phosphorodithioic acid, *O*,*O*-dimethyl ester, *S*-ester with 2-ethoxy-4-(mercaptomethyl)-Δ^2-1,3,4-thiadiazolin-5-one.
27193	Methidathion	Phosphorodithioic acid, *O*,*O*-dimethyl ester, *S*-ester with 4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one.
17292	Methyl parathion	Phosphorothioate acid, *O*,*O*-dimethyl *O*-(*p*-nitrophenyl) ester.
27144	Niagara NIA 9227	Phosphorothioic acid, *O*,*O*-diethyl ester, *O*-ester with 3-hydroxycoumarin.
27110	Rhodia 11783	Phosphorodithioic acid, *O*,*O*-dimethyl ester, *S*-ester with 3-(mercaptomethyl)-2-benzoxazolinone.
27111	Rhodia 11807	Phosphorodithioic acid, *O*,*O*-dimethyl ester, *S*-ester with 3-(mercaptomethyl)-2-benzothiazolinone.
27116	Shell SD 9020	Phosphorothioic acid, *O*-[2-chloro-1-(2,4-dichlorophenyl)vinyl] *O*,*O*-dimethyl ester.
27102	Shell SD 9098	Phosphorothioic acid, *O*-[2-chloro-1-(2,5-dichlorophenyl)vinyl] *O*-*O*-diethyl ester.
27122	Stauffer R–5762	Phosphorodithioic acid, *S*-(4,6-dimethyl-2-pyrimidinyl) *O*-ethyl *O*-propyl ester.
27123	Stauffer R–5763	Phosphorodithioic acid, *S*-(4,6-dimethyl-2-pyrimidinyl) *O*-ethyl *O*-isopropyl ester.
27184	Virginia Carolina VC 3–668.	Phosphorotrithioic acid, *O*-methyl *S*,*S*-dipropyl ester.

[1] Number assigned to compounds tested in Agricultural Research Service entomological investigations.

Direct-Contact Toxicity

The direct-contact toxicity of the candidate insecticides was determined by using solutions of technical-grade material in a 50–50 mixture by weight of Deobase and tetrachloroethylene. These preparations were applied to the insects as settling sprays inside cylindrical stainless-steel towers in the same manner as that described in MRR 885. The formulations used in the tests had concentrations of 3.4, 6.8, and 20.4 mg of insecticide per milliliter of the solution, which gave theoretical rates of application of 2, 4, and 11 $\mu g/cm^2$, respectively. Malathion was the standard for comparison. Solvent-treated insects were controls in all tests.

The room in which the towers were located was maintained at a temperature of 24° to 27° C during all tests. Four glass petri dishes of each insect species were exposed in each of four towers. Each petri dish contained 10 insects.

After exposure, the insects were removed from the towers and transferred to clean petri dishes. The bottoms of the dishes containing flour beetles were covered with kraft paper. The insects were held for postexposure observations in a room maintained at 27°±1° C and a relative humidity of 60±5 percent. The inactive, dead, and moribund insects were counted at various postexposure intervals.

Residue Toxicity

The residue toxicity of the candidate insecticides was determined by applying solutions of the insecticides to paper and aluminum surfaces and then confining the insects on the treated surfaces under open-end glass cylinders as described in MRR 885.

The insecticides were formulated in acetone and applied with an automatic blade applicator. The application gave deposit rates of 1, 5, 27, and 54 $\mu g/cm^2$ on aluminum surfaces and 4, 9, 43, and 86 $\mu g/cm^2$ on paper surfaces. The rates of 1, 5, and 27 $\mu g/cm^2$ on aluminum and 4, 9, and 43 $\mu g/cm^2$

on paper surfaces were tested as 1-day-old residues. The rates of 5, 27, and 54 µg/cm^2 on aluminum surfaces and 9, 43, and 86 µg/cm^2 on paper surfaces were tested as 28-day-old residues. Malathion was the standard for comparison. Acetone-treated sheets were controls.

Separate sheets were used for the initial and aged tests. For aging, the sheets were attached to fiberboard panels and stored at 27°±1° C and a relative humidity of 60±5 percent. Forty insects of each species were exposed to residues from each insecticide deposit. The flour beetles were exposed 4 and 24 hours to the 1- and 28-day-old residues, respectively. The larvae of the black carpet beetle were exposed 24 hours to both the 1- and 28-day-old residues. After exposure, the insects were transferred to clean petri dishes. The bottoms of the dishes that contained flour beetles were covered with kraft paper. The inactive, dead, and moribund insects were counted at various postexposure intervals. Exposure and postexposure tests were conducted in a room maintained at 27°±1° C and a relative humidity of 60±5 percent.

Vapor Toxicity

The vapor action of the experimental compounds was determined in 1-quart jars as described in MRR 885. The tests were conducted in a room maintained at 27°±1° C and a relative humidity of 60±5 percent. The candidate insecticides were formulated in acetone at 25 mg active ingredient per milliliter of solution. Four milliliters were introduced into each test jar. The jar was rolled on its side to spread the chemical on the inside surface, giving a rate of application of 215 µg/cm^2. Malathion and lindane were standards for comparison, and acetone-treated jars were checks. To allow the solvent to escape, the jars were stored open for 4 hours before making the exposures. Four replicate jars were tested for each insecticide for each insect species. Ten insects were exposed in each jar. The number of inactive, dead, and moribund insects was determined at various intervals of exposure.

RESULTS

The results of these evaluations of direct-contact, residue, and vapor toxicity against adults of the confused flour beetle and larvae of the black carpet beetle are presented in tables 2 through 7. No mortality occurred among the untreated insects. American Cyanamid 47772 was not tested against adults of the confused flour beetle because it showed little or no toxicity in exploratory tests against this species.

Direct-Contact Toxicity

As direct-contact toxicants, methidathion and Shell SD 9020 were more effective against both species than malathion (table 2). The toxicity of methyl parathion and Rhodia 11807 was greater than that of malathion against adults of the confused flour beetle. American Cyanamid 47772 and bromophos were more toxic than malathion to larvae of the black carpet beetle.

Residue Toxicity

The exposures of adults of the confused flour beetle to paper surfaces at 1 day and 28 days after application and to aluminum surfaces 1 day after application showed that residues of methyl parathion and Shell SD 9020 were more effective than residues of the other compounds tested (tables 3–5). Results of tests with adults of the flour beetle on aluminum surfaces showed that the most persistent residues were those of methidathion, methyl parathion, Rhodia 11783, Rhodia 11807, and Shell SD 9098 (table 6).

Exposures of black carpet beetle larvae to 1-day-old residues of the various compounds on paper showed that residues of Geigy GS–12968 produced the highest mortalities (table 3). On aluminum surfaces, residues of American Cyanamid 47772, bromophos, methyl parathion, Rhodia 11783, Shell SD 9020, and Shell SD 9098 were similar to malathion in toxicity to larvae of the black carpet beetle (table 4). Results of tests of aged residues showed that methidathion, methyl parathion, and Shell SD 9020 were the most effective as persistent residues on paper surfaces (table 5), and American Cyanamid 47772, Geigy GS–12968, Rhodia 11783, and Rhodia 11807 were the most effective as persistent residues on aluminum surfaces (table 6).

Vapor Toxicity

Several candidate insecticides showed high vapor toxicity to adults of the confused flour beetle and to larvae of the black carpet beetle. Those that showed the greatest effectiveness against both species were Chemagro 4637, Chemagro 4641, Chemagro 4671, methyl parathion, Shell SD 9020, and Virginia Carolina VC 3–668 (table 7). Bromophos was more effective than malathion against adults of the flour beetle, but not against larvae of the black carpet beetle.

CONCLUSIONS

The results will enable researchers studying control of stored-product insects on specific commodities to select those insecticides that show the most promise in a particular type of action. The candidate insecticides considered highly promising on the basis of their toxicity to the two species of insects tested are methidathion, methyl parathion, and Shell SD 9020. For situations in which insecticide vapors may be the best method (in enclosed space such as chests, crates, and tight buildings, or as grain protectants), further tests with Chemagro 4637, Chemagro 4641, Chemagro 4671, methyl parathion, Shell SD 9020, and Virginia Carolina VC 3-668 should be considered. Other factors, in addition to toxicity to the insects, may be important in selecting materials for further testing. These factors include mammalian toxicity, fate of residues, and the commercial potential of the chemical.

ACKNOWLEDGMENT

Evelyn M. Osborne, Pest Management, National Program Staff, verified the nomenclature of the chemical compounds.

TABLE 2.—*Percentage of inactive (I) or dead and moribund (D+M) confused flour beetle adults and black carpet beetle larvae after a ½-hour exposure to a candidate insecticide in aerosol form*

Insecticide	Intended deposit (μg/cm^2)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	336 hours after exposure	
		I	I	D+M	I	I	D+M
American Cyanamid 47772	11. 0	-----	-----	-----	100	100	86
	4. 0	-----	-----	-----	100	100	80
	2. 0	-----	-----	-----	100	100	73
Bay 52957	11. 0	97	94	87	100	100	53
	4. 0	11	11	10	100	100	61
	2. 0	0	0	0	100	100	50
Bromophos	11. 0	100	100	98	100	100	72
	4. 0	33	25	25	98	100	73
	2. 0	0	0	0	91	100	68
Chemagro 4637	11. 0	97	95	95	100	100	49
	4. 0	20	18	16	70	49	30
	2. 0	0	0	0	26	19	9
Chemagro 4641	11. 0	93	94	92	100	100	51
	4. 0	41	34	34	57	41	30
	2. 0	3	5	5	29	21	12
Chemagro 4671	11. 0	100	96	94	100	100	67
	4. 0	31	25	24	70	63	38
	2. 0	0	0	0	21	21	16
Geigy GS-12968	11. 0	100	100	95	100	100	78
	4. 0	94	90	80	100	100	63
	2. 0	67	60	49	100	100	48
Malathion [1]	2. 0	74	66	60	100	100	64

See footnote at end of table.

TABLE 2.—*Percentage of inactive (I) or dead and moribund (D+M) confused flour beetle adults and black carpet beetle larvae after a ½-hour exposure to a candidate insecticide in aerosol form*—Continued

Insecticide	Intended deposit ($\mu g/cm^2$)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	336 hours after exposure	
		I	I	D+M	I	I	D+M
Methidathion	11.0	100	100	100	100	100	92
	4.0	98	95	91	100	100	86
	2.0	90	85	76	100	100	75
Methyl parathion	11.0	100	100	100	100	100	44
	4.0	100	100	100	100	100	35
	2.0	100	100	100	100	100	32
Niagara NIA 9227	11.0	88	89	89	100	100	68
	4.0	60	62	62	100	100	67
	2.0	24	21	21	99	99	54
Rhodia 11783	11.0	93	92	88	100	100	87
	4.0	78	73	64	100	100	68
	2.0	64	55	51	100	100	58
Rhodia 11807	11.0	100	100	92	89	98	73
	4.0	98	94	82	84	80	66
	2.0	87	82	69	75	70	51
Shell SD 9020	11.0	100	100	99	100	100	89
	4.0	100	100	98	100	100	84
	2.0	100	100	92	99	100	77
Shell SD 9098	11.0	100	100	100	98	100	78
	4.0	77	74	70	26	55	47
	2.0	28	26	23	13	44	41
Stauffer R-5762	11.0	58	48	39	100	100	89
	4.0	0	2	2	41	24	8
	2.0	0	0	0	36	20	5
Stauffer R-5763	11.0	67	62	58	100	100	72
	4.0	1	0	0	55	51	24
	2.0	0	0	0	34	32	25
Virginia Carolina VC 3-668	11.0	100	100	94	100	100	68
	4.0	31	51	47	99	100	70
	2.0	0	0	0	92	83	51

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[1] Malathion data are the averages from 8 tests.

TABLE 3.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults exposed 4 hours and black carpet beetle larvae exposed 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface*

Insecticide	Rate of application ($\mu g/cm^2$)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
American Cyanamid 47772	43. 0	----------	----------	----------	100	100	45
	9. 0	----------	----------	----------	100	100	38
	4. 0	----------	----------	----------	72	62	22
Bay 52957	43. 0	22	18	18	100	95	12
	9. 0	0	0	0	100	100	35
	4. 0	0	0	0	90	90	22
Bromophos	43. 0	100	100	100	100	100	48
	9. 0	60	55	42	92	100	40
	4. 0	2	2	2	52	82	28
Chemagro 4637	43. 0	18	12	12	50	45	15
	9. 0	0	0	0	5	15	8
	4. 0	0	0	0	0	0	0
Chemagro 4641	43. 0	0	0	0	28	30	12
	9. 0	0	0	0	8	5	2
	4. 0	0	0	0	2	2	2
Chemagro 4671	43. 0	100	98	98	100	100	22
	9. 0	30	28	28	32	32	18
	4. 0	0	5	5	5	12	10
Geigy GS-12968	43. 0	2	2	2	100	100	68
	9. 0	35	25	25	100	100	82
	4. 0	18	12	12	100	100	75
Malathion [1]	43. 0	87	84	79	100	100	57
	9. 0	71	67	61	100	100	46
	4. 0	40	35	31	93	90	32
Methidathion	43. 0	85	70	65	100	100	58
	9. 0	65	60	55	100	100	35
	4. 0	65	48	40	100	100	20
Methyl parathion	43. 0	100	100	100	100	100	35
	9. 0	100	100	100	100	100	30
	4. 0	85	100	100	100	100	20
Niagara NIA 9227	43. 0	0	0	0	35	40	20
	9. 0	0	2	2	65	82	38
	4. 0	0	2	2	40	48	20
Rhodia 11783	43. 0	0	0	0	58	60	32
	9. 0	0	0	0	58	58	30
	4. 0	0	0	0	30	38	25

See footnote at end of table.

Table 3.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults exposed 4 hours and black carpet beetle larvae exposed 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface*—Continued

Insecticide	Rate of application (µg/cm²)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
Rhodia 11807	43. 0	0	0	0	15	25	18
	9. 0	0	0	0	15	35	30
	4. 0	0	0	0	0	2	2
Shell SD 9020	43. 0	100	100	98	100	100	65
	9. 0	100	100	98	95	98	33
	4. 0	88	92	85	48	62	28
Shell SD 9098	43. 0	85	60	58	100	100	50
	9. 0	5	0	0	18	18	15
	4. 0	0	0	0	2	10	2
Stauffer R–5762	43. 0	0	0	0	90	80	52
	9. 0	0	0	0	42	30	18
	4. 0	0	0	0	50	48	22
Stauffer R–5763	43. 0	0	0	0	80	80	42
	9. 0	0	0	0	32	32	18
	4. 0	0	0	0	28	28	12
Virginia Carolina VC 3–668	43. 0	30	25	25	100	100	50
	9. 0	0	0	0	40	25	8
	4. 0	0	0	0	2	8	5

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[1] Malathion data are the averages from 10 tests.

Table 4.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface*

Insecticide	Rate of application ($\mu g/cm^2$)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
American Cyanamid 47772	27.0				100	100	42
	5.0				100	100	60
	1.0				100	100	60
Bay 52957	27.0	100	100	100	100	98	12
	5.0	90	88	82	100	95	20
	1.0	55	40	40	98	100	22
Bromophos	27.0	100	100	100	100	100	62
	5.0	100	100	95	100	100	45
	1.0	75	75	70	82	82	38
Chemagro 4637	27.0	0	0	0	0	0	0
	5.0	0	0	0	0	0	0
	1.0	0	0	0	0	0	0
Chemagro 4641	27.0	0	2	2	0	0	0
	5.0	0	0	0	0	0	0
	1.0	0	0	0	0	0	0
Chemagro 4671	27.0	90	82	82	100	100	35
	5.0	0	0	0	0	0	0
	1.0	0	0	0	0	0	0
Geigy GS-12968	27.0	45	45	35	100	100	45
	5.0	18	8	8	100	90	45
	1.0	18	18	18	100	100	58
Malathion [1]	27.0	100	100	100	100	100	63
	5.0	100	99	97	100	100	61
	1.0	90	84	77	100	100	45
Methidathion	27.0	100	100	92	100	100	30
	5.0	92	88	75	100	100	40
	1.0	82	70	62	100	100	32
Methyl parathion	27.0	100	100	100	100	100	63
	5.0	100	100	100	100	100	42
	1.0	100	100	100	100	100	43
Niagara NIA 9227	27.0	12	20	15	40	60	32
	5.0	12	15	15	78	92	35
	1.0	0	0	0	88	90	40
Rhodia 11783	27.0	100	100	95	98	100	78
	5.0	60	62	60	48	75	45
	1.0	0	5	5	50	55	38

See footnote at end of table.

Table 4.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface*—Continued

Insecticide	Rate of application (µg/cm²)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
Rhodia 11807	27. 0	98	100	98	52	78	32
	5. 0	22	28	28	65	55	50
	1. 0	0	0	0	12	20	18
Shell SD 9020	27. 0	100	100	100	100	100	60
	5. 0	100	100	100	100	100	62
	1. 0	95	95	88	72	72	48
Shell SD 9098	27. 0	100	100	100	100	100	58
	5. 0	100	100	90	100	100	52
	1. 0	75	52	45	88	72	40
Stauffer R-5762	27. 0	100	100	100	100	100	45
	5. 0	70	62	48	100	100	48
	1. 0	5	2	0	92	95	28
Stauffer R-5763	27. 0	100	100	98	100	100	42
	5. 0	68	42	35	98	100	40
	1. 0	0	0	0	68	68	46
Virginia Carolina VC 3-668	27. 0	72	82	82	62	68	30
	5. 0	0	0	0	0	0	0
	1. 0	0	0	0	0	0	0

[1] Malathion data are the averages from 10 tests.

TABLE 5.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface*

Insecticide	Rate of application (µg/cm²)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
American Cyanamid 47772	86.0				20	12	0
	43.0				2	5	0
	9.0				2	2	2
Bay 52957	86.0	92	92	92	100	100	45
	43.0	12	10	8	100	100	50
	9.0	0	0	0	35	15	8
Bromophos	86.0	98	98	98	100	100	55
	43.0	80	82	82	52	50	28
	9.0	0	0	0	8	5	2
Chemagro 4637	86.0	0	0	0	0	0	0
	43.0	0	0	0	0	0	0
	9.0	0	0	0	0	0	0
Chemagro 4641	86.0	0	0	0	0	0	0
	43.0	0	0	0	0	0	0
	9.0	0	0	0	0	0	0
Chemagro 4671	86.0	0	0	0	0	0	0
	43.0	0	0	0	0	0	0
	9.0	0	0	0	0	0	0
Geigy GS-12968	86.0	85	82	75	92	92	42
	43.0	82	80	70	95	95	35
	9.0	0	0	0	25	25	5
Malathion [1]	86.0	100	100	100	100	100	54
	43.0	97	94	91	95	92	38
	9.0	22	20	19	26	23	11
Methidathion	86.0	100	100	100	100	100	62
	43.0	95	100	98	100	100	60
	9.0	2	5	5	38	28	12
Methyl parathion	86.0	100	100	100	100	100	58
	43.0	100	100	100	100	100	65
	9.0	100	100	100	100	100	62
Niagara NIA 9227	86.0	0	0	0	15	12	10
	43.0	0	2	2	22	28	12
	9.0	0	0	0	10	10	10
Rhodia 11783	86.0	22	22	20	25	25	18
	43.0	42	38	38	70	68	18
	9.0	15	18	12	12	15	12

See footnote at end of table.

Table 5.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface*—Continued

Insecticide	Rate of application ($\mu g/cm^2$)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
Rhodia 11807	86.0	75	72	72	25	30	30
	43.0	70	70	65	18	22	18
	9.0	0	0	0	0	0	0
Shell SD 9020	86.0	100	100	100	100	100	82
	43.0	100	100	100	92	85	60
	9.0	92	92	92	18	18	12
Shell SD 9098	86.0	100	100	100	80	82	35
	43.0	85	85	85	22	28	20
	9.0	0	0	0	0	0	0
Stauffer R–5762	86.0	90	82	82	85	85	48
	43.0	18	15	15	55	58	35
	9.0	0	0	0	20	10	8
Stauffer R–5763	86.0	15	18	15	40	32	15
	43.0	2	2	2	15	15	12
	9.0	0	0	0	0	0	0
Virginia Carolina VC 3–668	86.0	0	0	0	0	0	0
	43.0	0	0	0	0	0	0
	9.0	0	0	0	0	0	0

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[1] Malathion data are the averages from 10 tests.

TABLE 6.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface*

Insecticide	Rate of application (µg/cm²)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
American Cyanamid 47772	54.0				100	100	65
	27.0				100	100	40
	5.0				45	45	30
Bay 52957	54.0	100	100	100	100	100	30
	27.0	78	78	78	100	100	28
	5.0	2	2	2	0	0	0
Bromophos	54.0	92	92	92	88	98	52
	27.0	0	0	0	18	22	12
	5.0	0	0	0	0	0	0
Chemagro 4637	54.0	0	0	0	0	0	0
	27.0	0	0	0	0	0	0
	5.0	0	0	0	0	0	0
Chemagro 4641	54.0	0	0	0	0	0	0
	27.0	0	0	0	0	0	0
	5.0	0	0	0	0	0	0
Chemagro 4671	54.0	0	0	0	0	0	0
	27.0	0	0	0	0	0	0
	5.0	0	0	0	0	0	0
Geigy GS-12968	54.0	98	98	95	100	100	58
	27.0	98	98	98	98	90	40
	5.0	50	50	50	40	40	18
Malathion [1]	54.0	100	100	100	100	100	55
	27.0	94	95	94	99	98	44
	5.0	0	0	0	12	12	4
Methidathion	54.0	100	100	100	100	100	45
	27.0	100	100	98	100	100	45
	5.0	0	0	0	0	0	0
Methyl parathion	54.0	100	100	100	100	100	60
	27.0	100	100	100	88	85	50
	5.0	0	0	0	2	2	0
Niagara NIA 9227	54.0	42	52	52	42	60	20
	27.0	62	62	52	48	75	15
	5.0	52	55	55	68	70	12
Rhodia 11783	54.0	100	100	100	100	100	72
	27.0	95	95	95	100	100	52
	5.0	75	78	75	82	88	15

See footnote at end of table.

TABLE 6.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface*—Continued

Insecticide	Rate of application ($\mu g/cm^2$)	Percent of confused flour beetle adults affected—			Percent of black carpet beetle larvae affected—		
		24 hours after exposure	120 hours after exposure		24 hours after exposure	168 hours after exposure	
		I	I	D+M	I	I	D+M
Rhodia 11807	54.0	100	100	100	68	72	48
	27.0	100	100	100	70	80	52
	5.0	80	75	75	48	52	42
Shell SD 9020	54.0	100	100	100	100	100	80
	27.0	28	34	34	18	20	15
	5.0	0	0	0	0	0	0
Shell SD 9098	54.0	100	100	100	100	100	78
	27.0	100	100	100	78	78	48
	5.0	0	0	0	0	0	0
Stauffer R-5762	54.0	100	100	100	100	100	62
	27.0	90	85	85	100	100	45
	5.0	0	0	0	2	2	2
Stauffer R-5763	54.0	100	100	100	100	100	50
	27.0	85	20	18	50	50	18
	5.0	0	0	0	5	5	5
Virginia Carolina VC 3-668	54.0	2	2	2	0	0	0
	27.0	0	0	0	0	0	0
	5.0	0	0	0	0	0	0

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[1] Malathion data are the averages from 10 tests.

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Table 7.—*Percentage of inactive (I) or dead and moribund (D+M) insects among confused flour beetle adults and black carpet beetle larvae exposed to vapors of a candidate insecticide applied at 215 μg/cm² in 1-quart mason jars*

Insecticide	Percent of confused flour beetle adults affected after exposure for—			Percent of black carpet beetle larvae affected after exposure for—		
	24 hours	120 hours		24 hours	360 hours	
	I	I	D+M	I	I	D+M
American Cyanamid 47772				0	0	0
Bay 52957	0	0	0	82	100	65
Bromophos	0	95	82	0	100	68
Chemagro 4637	100	100	100	100	100	100
Chemagro 4641	100	100	100	100	100	100
Chemagro 4671	100	100	100	98	100	70
Geigy GS-12968	0	20	18	5	100	52
Lindane [1]	99	100	100	99	100	99
Malathion [1]	1	67	38	23	100	77
Methidathion	0	18	10	25	100	70
Methyl parathion	72	100	100	100	100	86
Niagara NIA 9227	0	0	0	0	52	20
Rhodia 11783	0	0	0	0	25	5
Rhodia 11807	0	0	0	0	0	0
Shell SD 9020	100	100	100	100	100	88
Shell SD 9098	0	10	8	2	100	72
Stauffer R-5762	0	2	0	0	100	63
Stauffer R-5763	0	0	0	0	100	52
Virginia Carolina VC 3-668	100	100	100	98	100	100

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[1] Lindane and malathion data are the averages from 10 tests.

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